

Cumulative Effects of Human Activities on Marine Mammal Populations

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LONG-TERM GOALS

The long-term goal of this project is to increase scientific understanding of cumulative effects of anthropogenic stressors, especially anthropogenic sound, on marine mammals.

OBJECTIVES

The National Academies of Sciences, Engineering, and Medicine has convened a volunteer committee that will:

- Review the present scientific understanding of cumulative effects of anthropogenic stressors on marine mammals with a focus on anthropogenic sound
- Assess current methodologies used for evaluating cumulative effects and identify new approaches that could improve these assessments.
- Examine theoretical and field methods used to assess the effect of anthropogenic stressors for short or infrequent exposure in the context of other known stressors (i.e. multiple stressors, both natural and anthropogenic), and chronic exposure in the context of other known stressors.

The review of methodologies will begin by focusing on ways to quantify exposure-related changes in the behavior, health, or body condition of individual marine mammals and assess the potential to use quantitative indicators of health or body condition to estimate changes in vital rates and, in turn, estimate the potential population-level effects. A critical outcome of the study will be reviewing and developing recommendation regarding current and potential approaches.

APPROACH

A committee composed of volunteer experts was convened by the National Academies. The volunteer committee is:

Dr. Peter L. Tyack, Chair—University of St. Andrews

Dr. Helen Bailey—University of Maryland Center for Environmental Science

Dr. Daniel E. Crocker—Sonoma State University
Dr. James E. Estes—University of California, Santa Cruz
Dr. Clinton Francis—California Polytechnic State University
Dr. John Harwood—University of St. Andrews
Dr. Lori H. Schwacke—NOAA
Dr. Len Thomas—University of St. Andrews
Dr. Douglas Wartzok—Florida International University

These committee members will use the objectives listed above to direct their information gathering from scientific literature, sponsors, and experts; will deliberate on the information; and write a report with recommendations. This report will be externally peer-reviewed and then released to the sponsors and the public. Committee biographies are below:

Dr. Peter L. Tyack, Chair—University of St. Andrews
Dr. Tyack is a professor of marine mammal biology at the University of St. Andrews in Scotland and a Senior Scientist Emeritus at the Woods Hole Oceanographic Institution. His research interests include social behavior and vocalizations of cetaceans, including vocal learning and mimicry in their natural communication systems and their responses to human noise. Dr. Tyack served on the National Research Council Ocean Studies Board from 2008-2013 and was a member of three previous NRC studies on marine mammals and sound, including the Committee on Describing Biologically Significant Marine Mammal Behavior, the Committee to Review Results of the Acoustic Thermometry of the Ocean Climate's Marine Mammal Research Program, and the Committee on Low-Frequency Sound and Marine Mammals. He has also served on ONR's Population Consequences of Disturbance Working Group. Dr. Tyack received his Ph.D. in animal behavior from Rockefeller University.

Dr. Helen Bailey—University of Maryland Center for Environmental Science
Dr. Bailey is a research assistant professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science. She has published over 30 journal articles specializing in marine mammals and sea turtles. She has studied habitat use of whales and dolphins, underwater sound levels and environmental impacts of offshore wind turbines on marine mammals, and migration pathways and hot spots of marine predators at the National Oceanic and Atmospheric Administration as part of the Census of Marine Life's Tagging of Pacific Predators project. She joined the University of Maryland in 2010 where her research focuses on studying patterns of habitat use and behavior of marine species, and its application to management and conservation. Dr. Bailey received her Ph.D. in Biological Sciences at the University of Aberdeen.

Dr. Daniel E. Crocker—Sonoma State University
Dr. Crocker is a professor of biology at Sonoma State University. His research has focused on both the physiology and behavior of marine mammals. He has published widely on the metabolism, endocrinology and toxicology of pinnipeds as well as their reproductive and foraging ecology. His current research is focused on the endocrine stress responses of marine mammals and how they vary with foraging success, fasting, and life-history stage. He is examining the interaction of stress responses with the reproductive and immune systems to better understand how stress has demographic impacts. The ultimate goal of this research is to better understand how marine mammals respond to

climate variability and anthropogenic stressors. Dr. Crocker received a Ph.D. in Biology from University of California, Santa Cruz.

Dr. James E. Estes (NAS)—University of California, Santa Cruz

Dr. Estes is a professor of ecology and marine biology at the University of California, Santa Cruz. He is an internationally known expert on marine mammals and a specialist in the critical role of apex predators in the marine environment. He has conducted field research in Alaska, California, Canada, Mexico, New Zealand, and Russia and has published more than 150 scientific articles, several books and monographs, and has served on the editorial boards for a variety of professional societies. He is a Pew Fellow in marine conservation, a Fellow of the California Academy of Sciences, and a member of the National Academy of Sciences. He received the Western Society of Naturalist's Lifetime Achievement Award in 2011 and the American Society of Mammologists' C. Hart Merriam Award in 2012. Dr. Estes received his Ph.D. in biology/statistics from the University of Arizona.

Dr. Clinton Francis—California Polytechnic State University

Dr. Francis is an assistant professor in the Department of Biological Sciences at California Polytechnic State University. His research spans evolutionary ecology, community ecology, and global change biology, with a focus on avian behavior and ecology. Most of his research seeks to understand how organisms and ecological communities respond to novel environmental conditions created by human activities with an emphasis on how organisms and ecological systems respond directly and indirectly to changes in the acoustical environment. Current work includes i) revealing links between anthropogenic forces, chronic stress and fitness, ii) using manipulative field experiments to quantify the costs of anthropogenic noise on reproductive success and iii) understanding how soundscapes mediate interactions between human and ecological systems. Dr. Francis received his Ph.D. in ecology and evolutionary biology at the University of Colorado.

Dr. John Harwood—University of St. Andrews

Dr. Harwood is a professor of biology at the University of St. Andrews. He is a former director of the Sea Mammal Research Unit, which advises the U.K. and Scottish governments on the conservation of seals and whales. He was also the director of the Centre for Research into Ecological and Environmental Modelling from 2004 to 2009. Currently, his main interest is in developing methods for assessing and mitigating the effects of anthropogenic disturbance on marine ecosystems. Additional research involves exploring the effects of individual variation and spatial structure on the population dynamics, genetics and epidemiology of vertebrates, particularly marine mammals. He is currently co-chair of ONR's Population Consequences of Disturbance Working Group. Dr. Harwood received his Ph.D. in zoology from the University of Western Ontario.

Dr. Lori H. Schwacke—NOAA

Dr. Schwacke is a biostatistician for NOAA's National Centers for Coastal Ocean Science and Chief of the Oceans and Human Health Branch. Recognizing the parallels of studying disease in human populations and in populations of marine protected species, her research focuses on the application of statistical models developed for human medicine to assess the risk of stressors such as environmental contaminants, infectious disease, and natural toxins on marine mammals. Most recently, she has been integrally involved in the assessment of injuries to nearshore dolphin populations in the Gulf of Mexico following the *Deepwater Horizon* oil spill. Dr. Schwacke received her Ph.D. in biostatistics, epidemiology, and systems science from the Medical University of South Carolina.

Dr. Len Thomas—University of St. Andrews

Dr. Thomas is an ecological statistician at the University of St. Andrews. He is the director of the Centre for Research into Ecological and Environmental Modelling and a reader in the School of Mathematics and Statistics. He is also part of the UK National Centre for Statistical Ecology and the Scottish Oceans Institute. His main research areas focus on the development of methods and software for estimating the size, density, and distribution of wild animal and plant populations, and the use of computer-intensive methods to fit and compare stochastic models of wildlife population dynamics and animal movement. Of relevance to this committee, he has led research projects developing methods for quantifying marine mammal density, distribution and trends (particularly from passive acoustic data), analyzing cetacean behavioral response studies and quantifying the population consequences of anthropogenic disturbance. He has also served on the BP-sponsored Working Group on Assessment of Cumulative Effects of Anthropogenic Underwater Sound, as well as ONR's Population Consequences of Disturbance Working Group. Dr. Thomas received his Ph.D. in Forestry from the University of British Columbia.

Dr. Douglas Wartzok—Florida International University

Dr. Wartzok is a professor of biology at Florida International University, and the former provost, executive vice-president, and chief operation officer. His research on marine mammals has taken him from the Arctic Ocean to Antarctica to study seals, whales, and walrus. His research focuses on behavioral and physiological ecology of marine mammals; sensory systems involved in under-ice navigation by seals; and psychophysiological studies of captive marine mammals. For the past decade he has been involved in the issue of the effects of naval anti-submarine warfare sonar on marine mammals, in particular beaked whales. He recently served as Chairman of the Committee of Scientific Advisors for the U.S. Marine Mammal Commission and is a former editor of *Marine Mammal Science*. He is a current member of the Ocean Studies Board, served on the NRC Committee on Assessing Ambient Noise in the Ocean with Regard to Potential Impacts on Marine Mammals, and chaired the Committee on Determining Biological Significance of Marine Mammal Responses to Ocean Noise. Dr. Wartzok received his Ph.D. in Biophysics (Neurophysiology) from the Johns Hopkins University.

WORK COMPLETED

A call for nominations was sent out on January 26, 2015. Committee nominations were solicited in the following fields: environmental risk modeling; cumulative effects; ocean acoustics; marine bioacoustics; marine mammal ecology, behavior, and/or physiology; marine mammal health (e.g., toxicology); terrestrial and/or marine population biology; quantitative ecology; population consequences of disturbance; or other relevant fields. From the approximately 100 nominees, a committee was composed by National Research Council staff and then approved by the President of the National Academy of Sciences. The committee held its first meeting on June 16-17, 2015. Representatives from the four sponsoring agencies (ONR, NOAA, MMC, and BOEM) were asked to address the following questions in a brief to the committee:

- Why is your agency interested in the topic of cumulative impacts of anthropogenic stressors on marine mammals?
- What previous or current work on this topic has your agency been involved with?
- Which marine mammals/what stressors are of particular concern?
- How well have effects of particular stressors on marine mammals been documented to date?

- Is it possible to understand/document cumulative effects without understanding/documenting particular effects? Or vice versa?
- How might the study be used? For example, how might NOAA use study results to change permits and authorizations?
- What would be pertinent outcomes that your agency could use? What would not be helpful?

Horst Greczmiel from the Council of Environmental Quality was also invited to speak on how cumulative effects are addressed in environmental regulation, with emphasis on NEPA.

RESULTS

The committee is still in its information-gathering stage. The first meeting focused on agency needs and environmental requirements. Future meetings will focus on related fields that are exploring approaches to dealing with cumulative effects; for example, terrestrial ecology and human health.

IMPACT/APPLICATIONS

This will have implications for increasing scientific understanding of cumulative impacts of environmental stressors on marine mammals, which has direct application on laws regulating anthropogenic noise, pollutants, etc.

RELATED PROJECTS

None.